

Glacial Modification of Terrain

Chapter 19

Last Ice Age

- The Pleistocene Epoch
 - Began- 2 million years ago- maybe ended 10,000 years ago
 - Impact of glaciers on the landscape
 - Form when year to year accumulation of snow is greater than the amount that melts during the summer
 - Have an overwhelming impact on the landscape
 - Moves everything in its path
 - About 7% of all contemporary erosion is done by glaciers
 - Modifies flat landscapes with post glacial slope, drainage, and superficial material
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Glaciations Past and Present

- Pleistocene Glaciation

- Boundaries unknown- may have started 1.8 million years ago or earlier
 - About 2.5 million years ago- there was an “amplitude” in climate fluctuations- causing some parts of the Northern Hemisphere to be covered by glaciers
 - Glaciologists are changing their thoughts that this epoch may be only 9000 years ago – whether this is a Glacial or interglacial period
 - End of the Pleistocene epoch in North America known as the “Wisconsin” glacial stage approximately 10,000 years ago
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Glaciations Past and Present

- The period since then is known as the “Holocene” epoch. Could be either post glacial or an interglacial interlude
- At maximum Pleistocene extent, ice covered one third of the total land area of Earth



Indirect Effects of Pleistocene Glaciation

- Periglacial processes- the erosion & deposition done by the prodigious amounts of melt water released as the glaciers melted
 - Frost weathering associated with solifluction of frozen subsoil
- Sea-level Change- more water stored in the ice – less water in the oceans – when glaciers melted ocean levels went up
- Crustal depression- enormous weight of accumulated ice on continents caused portions of Earth's crust to sink- When ice melted the crust would rebound- Isostatic adjustment in portions of Canada and Europe- They are still rising

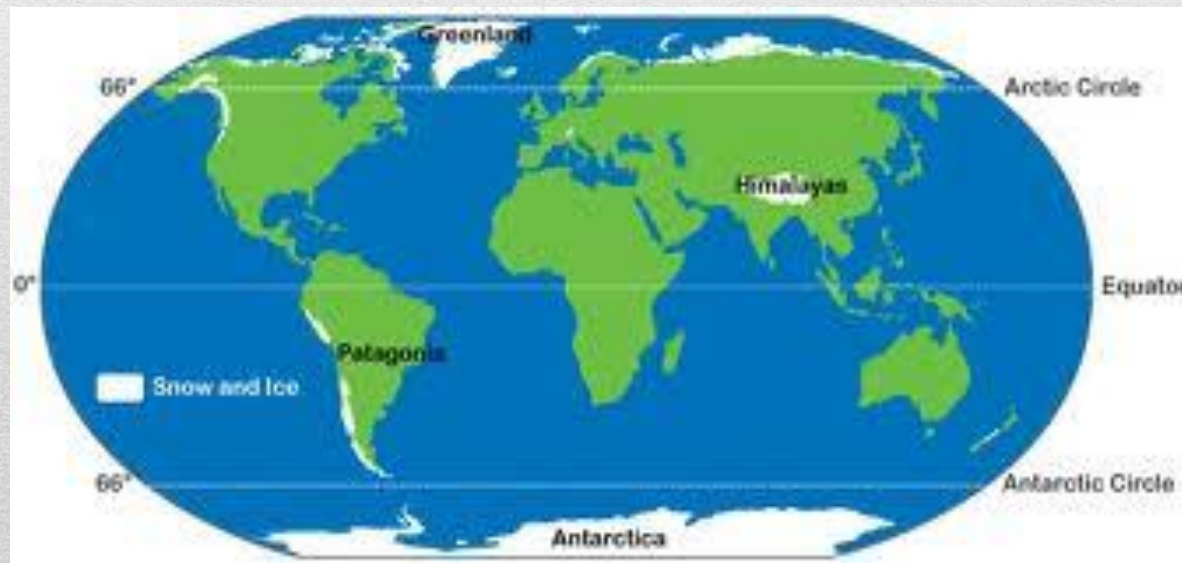


Indirect Effects of Pleistocene

- Pluvial (increased rain) developments- during glaciation period. There was a considerable increase in precipitation, and a decrease in evaporation
 - Result ‘pluvial effects’ created many lakes where previously there had been none
 - Most have drained or significantly reduced in size but have left lasting imprint- example Lake Bonneville
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Contemporary Glaciation

- Compared to Pleistocene glaciation, the extent of ice covering the continent surfaces today is very small – 96% in Antarctica and Greenland

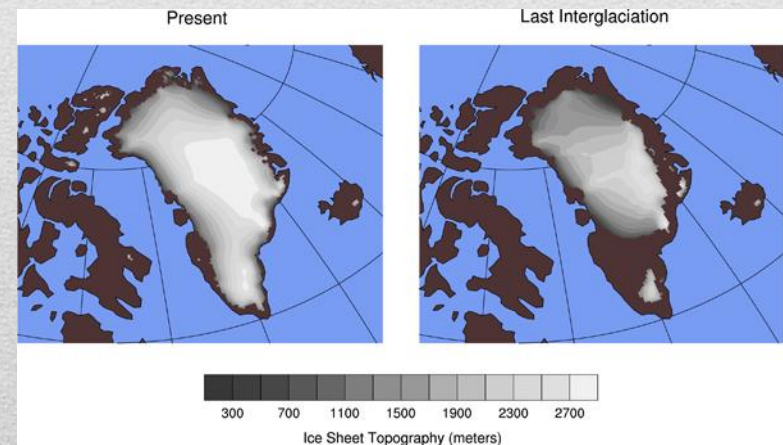
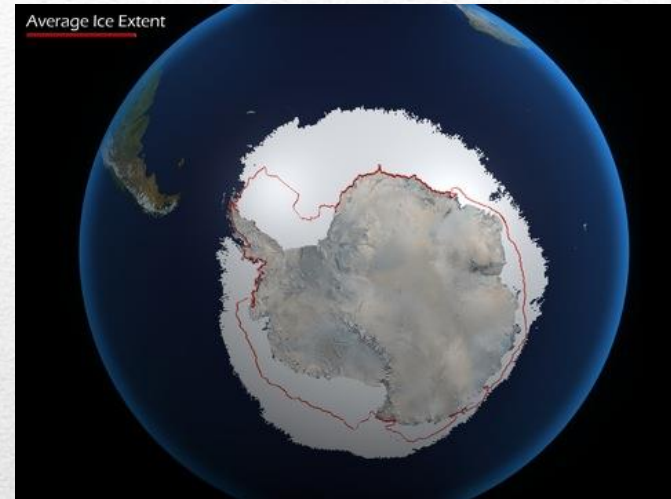


Antarctic Ice Cap

- 98% of its surface covered by glacial ice-representing 85% of the world's land-ice.
 - This ice is more than 13,000 feet thick
 - Continent and its ice sheets can be thought of two unequal sections separated by Transantarctic Mountains
 - West Antarctica is general mountainous-contains the “Dry Valley” area which consists of about 1500 sq. miles, which, because the winds blast away snow & keep precipitation out; ice does not build up.
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Antarctica Ice Cap

- The three major parallel valley's contain several large lakes, a number of ponds- and a river that runs 1 to 2 months a year
- East Antarctica - extensive – large broad plateau
- West Antarctica - 8000 foot above sea level
- Greenland Ice Cap – less extensive- 670,000 sq. miles



North American Glaciers

- In conterminous U. S., most glaciers are on the Pacific Northwest and more than half of these are in the north Cascade Mountains of Washington
 - In Alaska there are 75,000 sq. miles of glacial ice, amounting to about 4 percent of the total area of the state.
 - The largest Alaskan glacier is the Bering Glacier, near Cordova, which covers 2250 sq. miles and is more than twice the size of Rhode Island.
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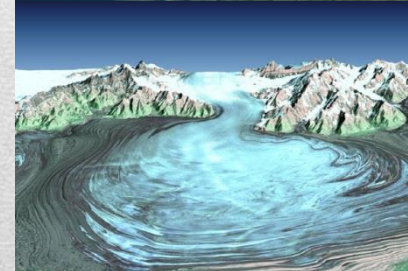
Types of Glaciers

- Continental Ice sheets
 - Non-mountainous areas of the continents
 - During the Pleistocene Epoch-vast blankets of ice complete inundated the underlying terrain to the depths of hundreds or thousands of meters
 - Around the margins of the ice sheets, glaciers form.
 - Only exist in Greenland and Antarctica



Types of Glaciers

- **Mountain Glaciers**
 - Highland Icefields – accumulations of unconfined sheet of ice covering a few hundred or few thousand of square kilometers .
 - Valley glaciers - outlet tongues of ice traveling down valleys out of the icefields
 - Piedmont glacier - the glacier that escapes the valley
 - Alpine glaciers – individual glaciers in mountain tops
 - Cirque glaciers form in basins of mountain tops



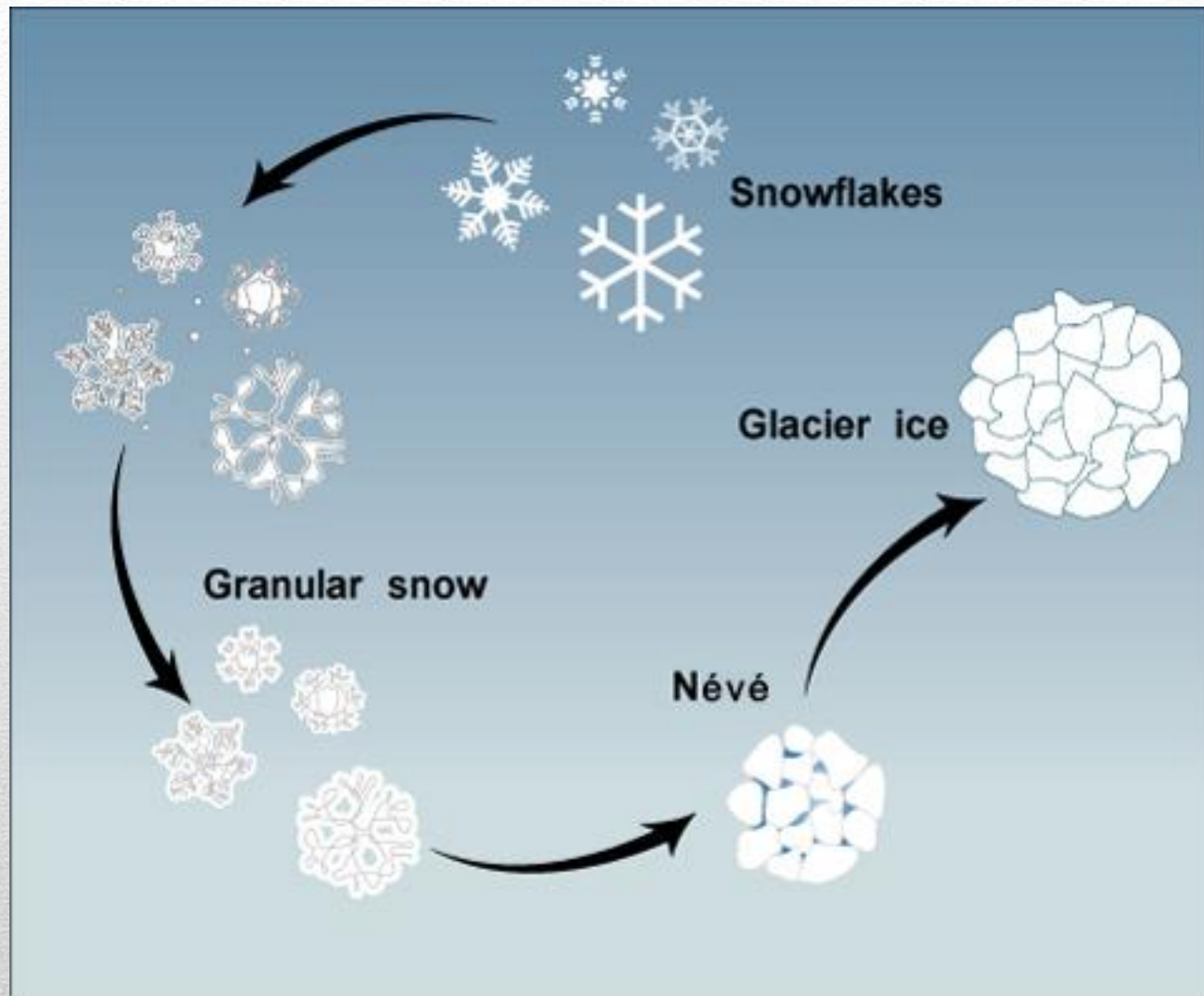
Glacier Formation and Movement

- Glaciers require certain circumstances to form and then depend on just the right combination of temperature and moisture to survive.
- Need a balance between:
 - Accumulation of ice by incorporation of snow
 - Ablation – wastage of ice through melting and sublimation



Glacier Formation and Movement

- Changing Snow to Ice
 - Snow is changed to ice by compression and coalescence, following a sequence from snowflake to granular snow to neve to glacier ice
 - Neve or firn – compacted snow
 - Glaciers divided into two portions
 - Accumulation zone – upper portion where new ice is formed
 - Ablation zone – lower zone where ice is lost due to less snow
 - Equilibrium line – where accumulation and ablation are equal
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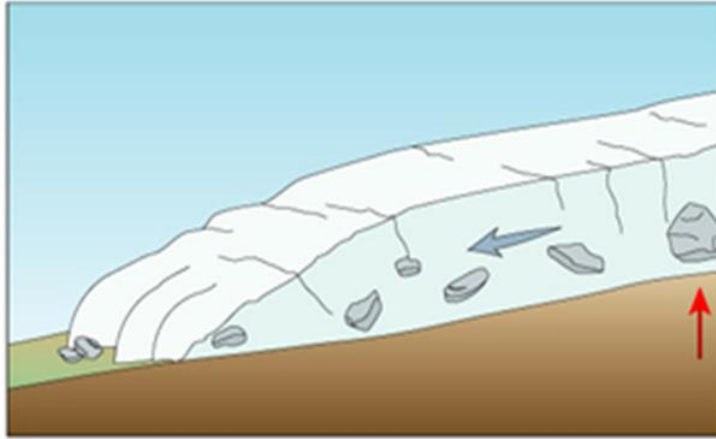


Glacial Movement

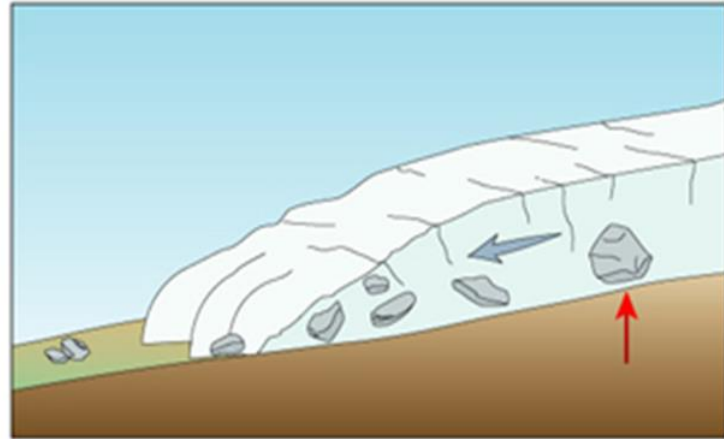
- The “flow” of a glacier involves an orderly sliding of ice molecules one over the other
- A flowing glacier is not necessarily an advancing glacier.
 - A glacier oozes outward from the edge of an ice sheet or down-valley from the toe of an alpine glacier.
 - Laminar flow – internal planes which causes different portions to move with different speeds
 - Basal slip – movement at the bottom of the glacier on a film of water
- Glacier Flow versus Glacier Advance
 - Glaciers are always flowing, either outward or downhill
 - **BUT** glaciers are not always advancing depending on the balance between the accumulation and ablation.



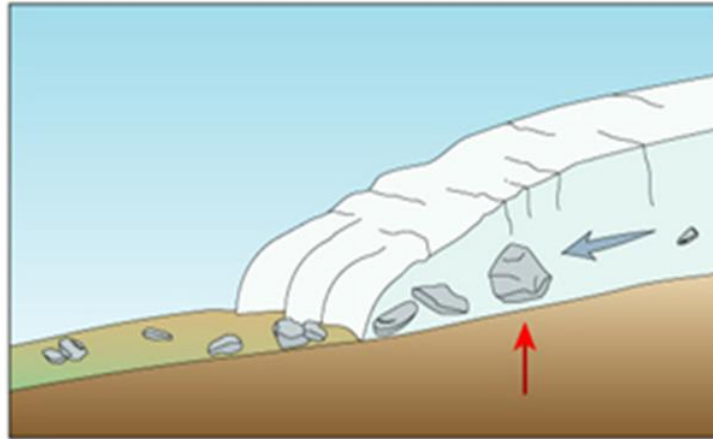
Glacial Movement



(a)



(b)



(c)

Effects of Glaciers

- **Erosion by Glaciers**
 - **Glacial Plucking** – rock particles beneath the ice are grasped as meltwater refreezes in bedrock joints and fractures where frost refreezes in bedrock joints and fractures where frost wedging further loosens the rock.
 - **Glacial Abrasion** - Bedrock is worn down by rock debris being dragged along by moving ice



Transportation by Glaciers

- Glaciers move immense amounts of rocks
 - Glacier Flour- rock load ground very fine
 - Most material transported plucked or abraded from underlying surface
 - Flowing water during the summer months help with the transportation of debris
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Deposition by Glaciers

- One of the important roles of glaciation is landscape modification
 - Glaciers move material from one region to another
 - Drift – general term for all material moved by glaciers
 - Till – rock debris deposited by moving or melting ice with no meltwater flow or redeposition involved
 - Glacial Erratics – outsized boulders are included in the glacial till
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Deposition by Meltwater

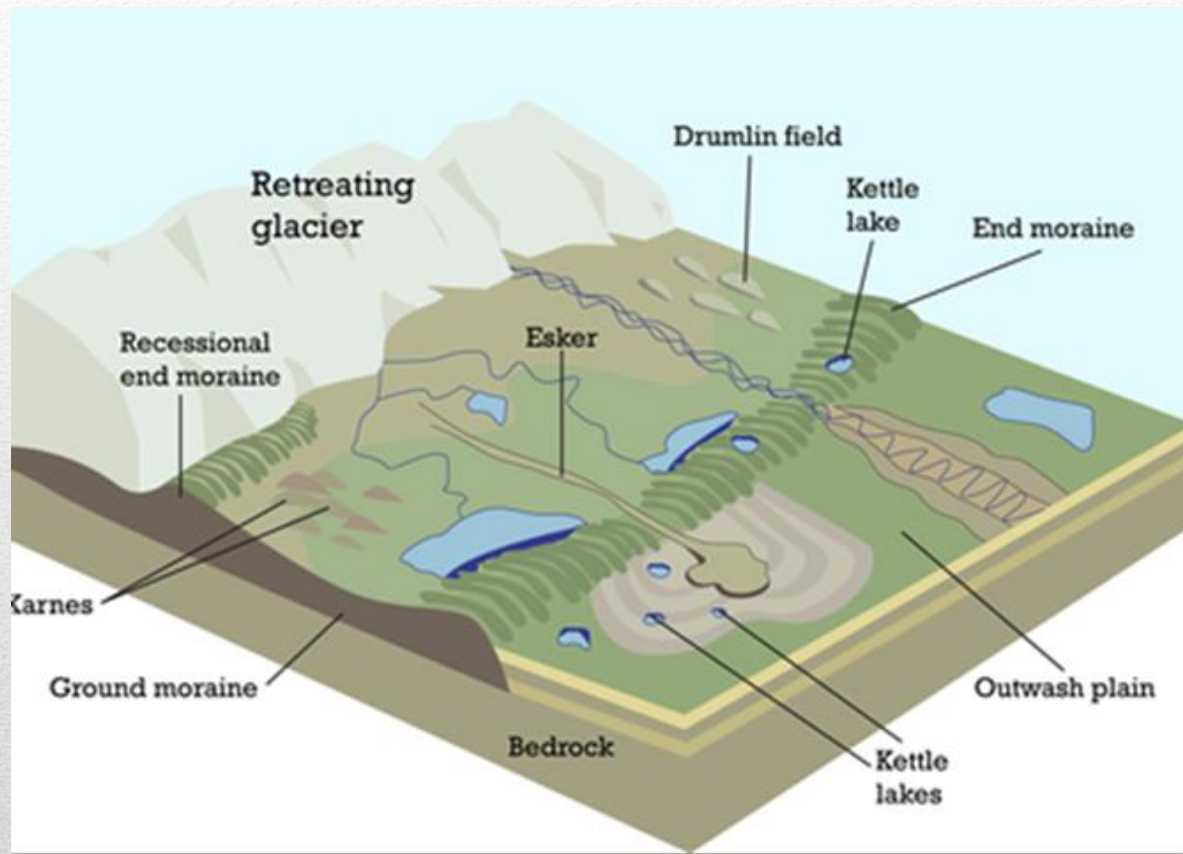
- **Glacial runoff has several peculiarities**
 - Peak flows in midsummer
 - Distinct day-and-night different in volume
 - Large silt content
 - Occasional floods
 - **Glaciafluvial deposition** - occurs around the margins of all glaciers
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Continental Ice Sheets

- **Development**- in subpolar and mid latitude locations and then spread outward in all directions poleward
 - **Initial Flow**- channeled by the preexisting terrain along valleys and other low-lying areas
 - **Erosion by Ice Sheets**
 - **Ice sheets gently undulate the surface**
 - Notably produces a profusion of lakes
 - Roche Moutonee- Hills generally sheered off and rounded
 - **Deposition by Ice Sheets**
 - **Till** is deposited heterogeneously and extensively without forming identifiable topographic features- a veneer of unsorted debris
 - **Veneer** is sometimes quite shallow and does not mask the original topography call Till Plain
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Deposition of Ice Sheets

- **Moraine** – general term for glacial deposited landforms composed entirely or largely of till
 - **Terminal Moraine** - a ridge of till that marks the outermost limit of the glacial advance
 - Formed when a glacier reaches equilibrium point and so it is wasting is at the same rate as it is nourished
 - **Recessional Moraine** – the ridges that mark positions where the ice front was temporarily stabilized during the retreating glaciers
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Deposition of Ice Sheets

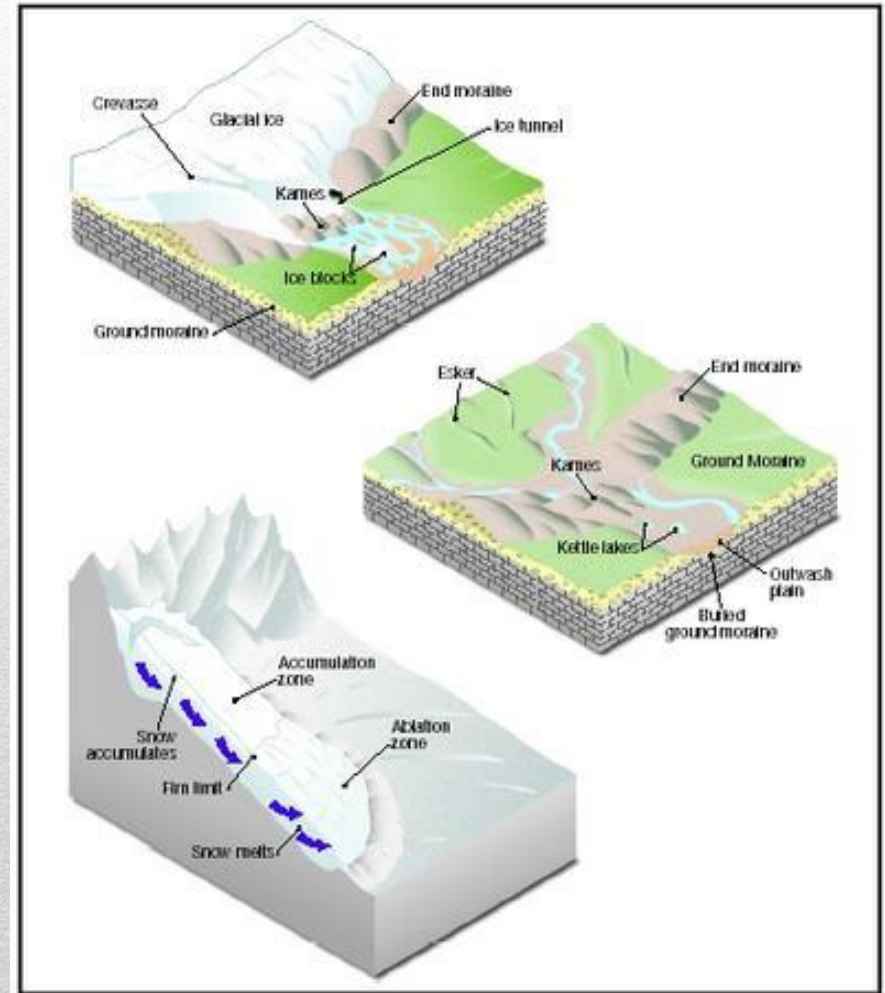
- **Ground Moraine** – large quantities of till laid down from underneath the glacier rather than from its edge
 - **Kettles** – form when large blocks of ice left by retreating glaciers become surrounded or even covered by glacial drift – after the ice block melts, the moraine surface collapse leaving an irregular
 - **Drumlin** – a elongated hill smaller than moraines but composed of similarly unsorted till.
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Glaciafluvial Features

- Deposition or redeposition of debris by ice-sheet meltwater produces certain features.
 - Stratified drift-some sorting of the debris carried along by the meltwater
 - Outwash plains are smooth, flat alluvial aprons deposited beyond recessional or terminal moraines by streams issued from the ice.
 - Valley train – deposit of glaciafluvial alluvium confined to a valley bottom
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Glaciafluvial Features

- **Eskers** – long sinuous ridges of stratified drift
- **Kames** – small steep mounds or conical hills of stratified drift found sporadically in areas of ice-sheet deposition.
- **Kame-and-kettle topography** - morainal surfaces containing a number of mounds and depressions



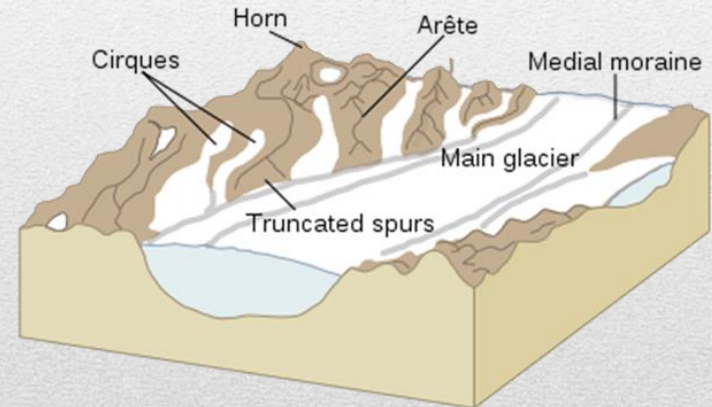
Mountain Glaciers

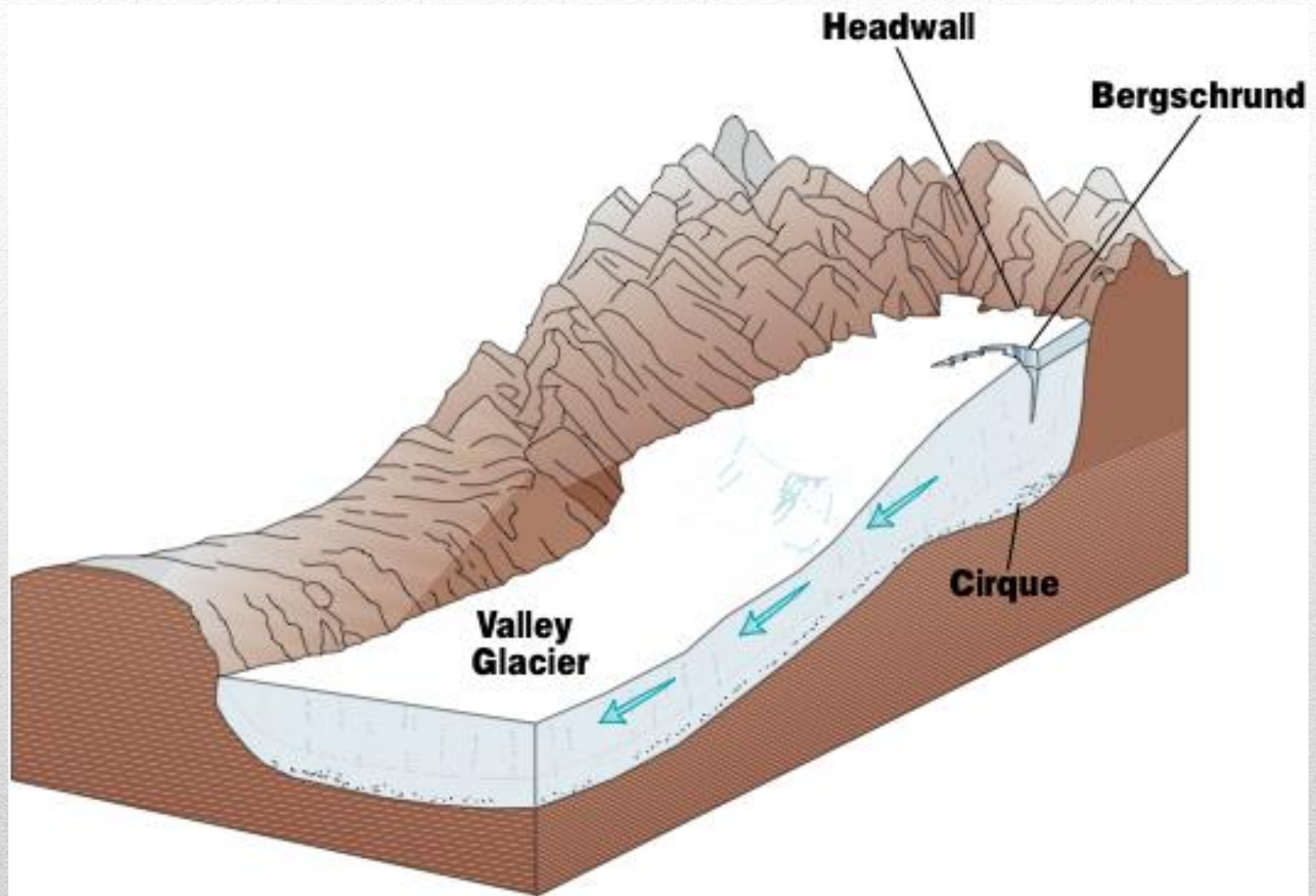
- Most of the world's high mountain regions experienced extensive Pleistocene glaciation and many mountain glaciers exist today
 - Effect of glacial action, particularly erosion, on mountainous topography is to create preglacial slope and relief
 - **Development and Flow** – Individual alpine glaciers usually form in sheltered depressions near the heads of stream valleys
 - **Erosion by Mountain Glaciers**
 - **In the High Country** –
 - **Cirque** – a broad amphitheater hollowed out at the head of a glacial valley
 - The first landform feature produced by alpine glaciation, essentially being quarried out of the mountainside
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Mountain Glaciers

- **Arete**- where several cirques have been cut back into an interfluvium from opposite sides of a divide, leaving a narrow, jagged serrated spine of rock, that may be all that is left of a ridge crest.
- **Col** – the sharp-edged pass or saddle through the ridge that is being cut back by two adjacent cirques
- **Horn** – a steep-sided, pyramidal rock pinnacle formed by expansive quarrying of the headwalls where three or more cirques intersect.
- **Tarn** – a depression formed to hold water after glacial ice in a cirque has melted away.





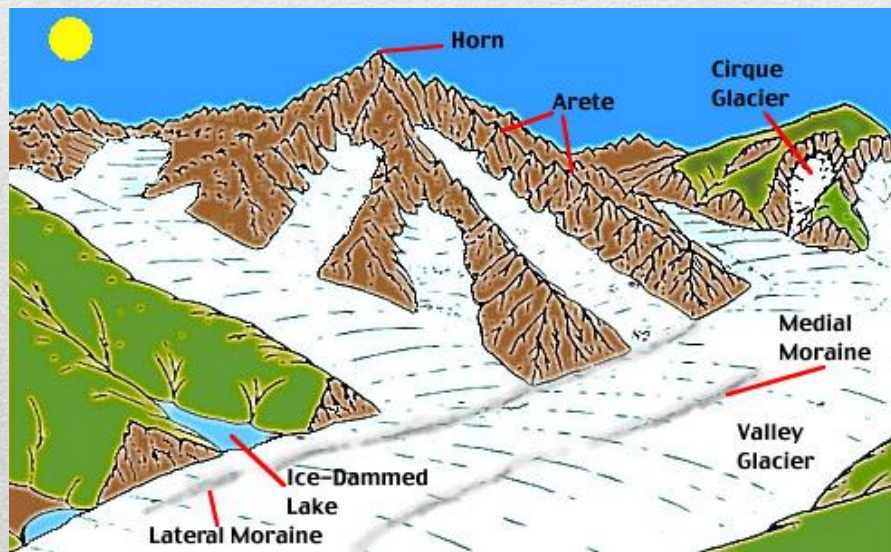
Mountain Glaciers

- In the valleys
 - A glacier moves down a mountain valley with much greater erosive effectiveness than a stream.
 - The principal erosive work of a valley glacier is to deepen, steepen, and widen its valley.
 - The cross-sectional profile is changed from a stream-cut “V” shape to an ice-eroded “U” shape called a Glacial Trough
 - Valley is straight because the glacier does not meander, but grinds away the protruding spurs that separate side canyons called Truncated Spurs.



Mountain Glaciers

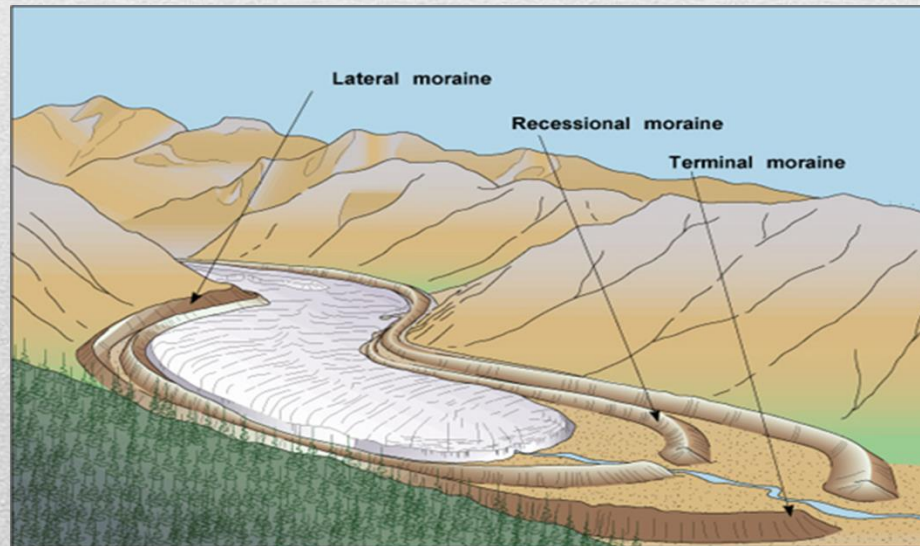
- **Glacial steps** – irregular parts that are gently sloping, flat, or steep, with some excavated depressions alternating in erratic sequence
- **Paternoster lakes** – shallow lakes
- **Hanging valleys** – tributary valleys are characteristically perched high along the sides of the major troughs.





Deposition of Mountain Glaciers

- The principal depositional landforms associated with mountain glaciation are moraines.
- Lateral moraines – well-defined ridges of unsorted debris built up along the sides of valley glaciers.
- Medial moraine – a dark band of rocky debris



The Periglacial Environment

- **Periglacial** – the perimeter of glaciation
 - More than a 20% of the world's land area is presently periglacial, but most of this was covered by ice on one or more occasions during the Pleistocene epoch.
 - Most are found in the Northern Hemisphere because the Southern Hemisphere has less land.
 - **Patterned Ground** – generic name applied to various geometric patterns that repeatedly appear over large areas.
 - **Proglacial lakes** – where ice flows across a land surface, the natural drainage is either impeded or blocked, and meltwater from the ice can become impounded against the ice front
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Causes of the Pleistocene

- Why do we have Ice Ages?
 - The accumulation of ice masses more or less simultaneously at various latitudes in both hemispheres but without uniformity
 - The apparently concurrent development of pluvial conditions in drylands areas
 - Multiple cycles of ice advance and retreat, including both minor fluctuations over decades and centuries and major glaciations and deglaciations over tens of thousands of years
 - Eventual total deglaciation, either actual (past geologic era) or potential (for the Pleistocene epoch)
 - Are we still in an Ice Age?????
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